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## DESIGN AND SIMULATION OF EVA TOOLS FOR FIRST SERVICING MISSION OF HST

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## ABSTRACT

The Hubble Space Telescope (HST) was launched into near-earth orbit by the Space Shuttle Discovery on April 24, 1990. The payload of two cameras, two spectrographs, and a high-speed photometer is supplemented by three fine-guidance sensors that can be used for astronomy as well as for star tracking. A widely reported spherical aberration in the primary mirror causes HST to produce images of much lower quality than intended. A Space Shuttle repair mission in late 1993 will install small corrective mirrors that will restore the full intended optical capability of the HST.

The First Servicing Mission (FSM) will involve considerable Extra Vehicular Activity (EVA). It is proposed to design special EVA tools for the FSM. This report includes details of the Data Acquisition System being developed to test the performance of the various EVA tools in ambient as well as simulated space environment.

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# Design and Simulation of EVA Tools For First Servicing Mission of HST

## 1. Introduction:

The performance of EVA tools in space environment can be predicted by testing these tools in vacuum and in temperature extremes in space. The performance of EVA tools is based on various benchmarks such as maximum attainable torque, frequency response, and life of the tools. Of these various benchmarks, torque and speed can be measured by torque transducers and encoders. The data acquisition system designed to test the EVA tools make use of these two sensors. However, the data acquisition system can be easily modified to incorporate other analog and digital signals with little modifications.

## 2. The Data Acquisition System:

The block diagram of the data acquisition system is as shown in Fig. 1. The transducer #8241 has built-in strain gage and encoder to generate analog and digital signal corresponding to torque and speed of the EVA tool being tested. These signals are taken to GSE 290 Data-Stat, a meter which displays torque as well as angle of rotation and to plug-in data acquisition board. This is accomplished by cable # 299210-6E080 and parallel connection cable as shown in the Fig. 1. The power to the GSE 290 Data-Stat is supplied through A/C adapter. The cable carrying transducer signals to data acquisition board in a PC is connected to Terminal blocks. Two such terminal blocks are used in this system. One for analog signals which require signal conditioning. And the other TTL compatible digital signals which are directly connected to the data acquisition board through feedthrough terminal block, feedthrough panel and SCXI-1340 MIO-16 cable # 776574-40. The analog signals from torque transducer are connected to the data acquisition board through SCXI-1300 terminal block, SCXI-110 multiplexure-signal conditioner and SCXI-1340 MIO-16 cable. The SCXI-1100 multiplexure-signal conditioner has low pass and high pass filters. The analog signals are conditioned in the form of noise isolation, voltage scaling and signal amplification. An application software package based on NI-DAQ (National Instrument software system) is developed to control data acquisition functions for the PC based data acquisition boards.

The various cable connections for torque transducer and encoder connector (Bendix-9219) to data acquisition board connector AT-MIO-16F-5 is as shown Fig. 2

## 3. Computer Program:

An application program(PRT.BAS) developed for testing EVA tools, more particularly the Power Ratchet Tool is based on NI-DAQ software

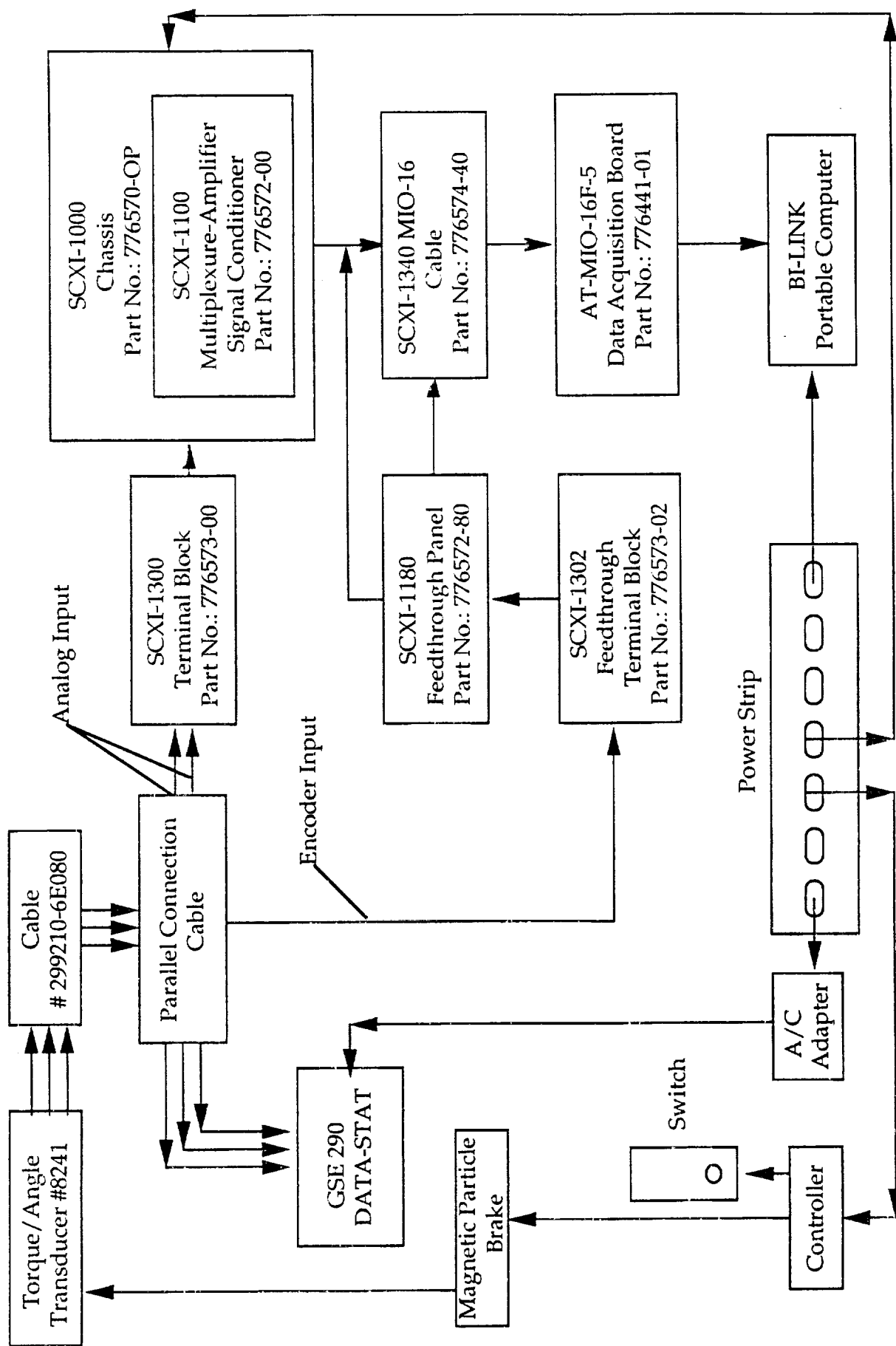


Fig. 1 Data Acquisition System

GSE 299210 2E080 CABLE

Bendix-9219  
P/T0 6A-12-10S (SR)

AMP Metal Shell 748676-1  
(DB-9 Connector)

A	+ POWER (10 VDC-TORQUE TRANSDUCER)	7
B	- POWER	2
C	+ SIGNAL	6
D	- SIGNAL	1
E	GROUND	3
F	+ POWER (5 VDC @ 120 mA MAX: ENCODER)	7
G	PHASE A (LEAD)	8
H	PHASE B (TRAIL)	4
J	GROUND	3
K	DATA PIN (ID RAM)	5

AT-MIO-16P-5 I/O Connector

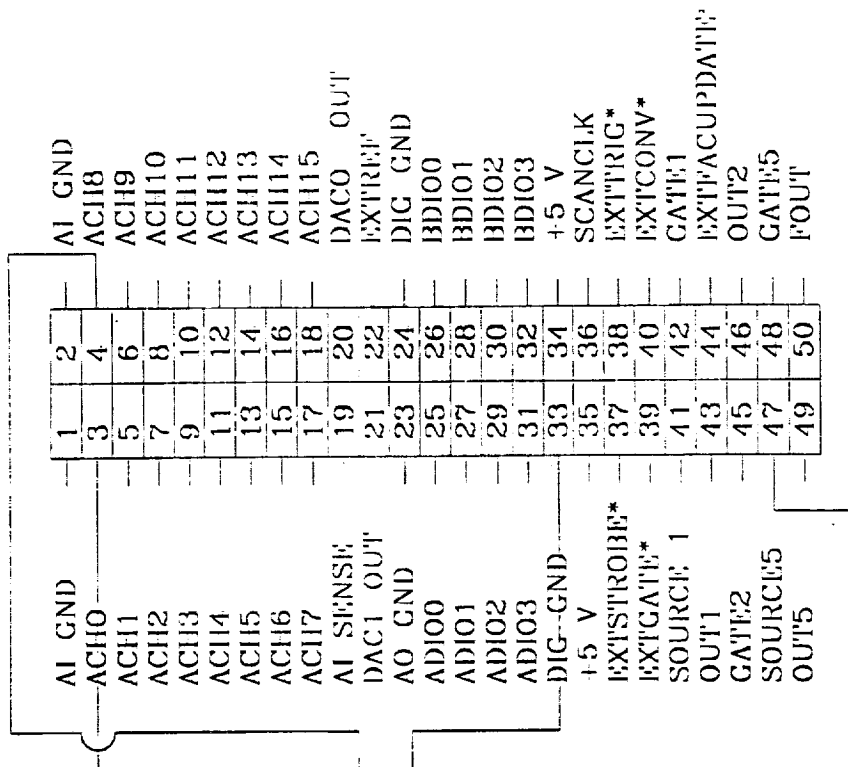


Fig. 2 AT-MIO 16-P-5 I/O Connector

system supplied by National Instruments. The application software has the capability to generate sequential data files and compute torque, angle and speed at pre-programmed torque speed characteristics of the tool. The sequential steps to run this application is as shown in Appendix-I.

4. Closure:

Although the application software "PRT.BAS" is developed for testing Power Ratchet Tool, it can be used other applications requiring measurement of torques and rpm. It also can be used to measure ultimate torque capacities of various fasteners.



## APPENDIX - I

## GUIDELINES FOR PC BASED DATA ACQUISITION

- Notes: 1. User response is underlined.  
2. Comments are in *(Italics)*.  
3. Symbol ↓ Stands for Return Key  
4. For Any Software Bugs Call Dipak Naik (301-474-0832 OR 286-1324)

### HARDWARE SETUP:

1. Power On:
  - a. Computer
  - b. SCXI 1000 (Signal Conditioning Module)
  - c. GSE Data-Stat
2. The CAPS LOCK and The NUM LOCK Keys On The Computer Keyboard Should be "ON"

### SOFTWARE SETUP:

1.  
*(All The Executable File For Data Acquisition Are In VBDOS Directory. Key-In Following Command To Switch To VBDOS Directory.)*

C:\> CD VBDOS↓  
C:\> VBDOS>

2.  
C:\>VBDOS>PRT↓ *(Run PRT.EXE)*

3.  
DATA STORAGE FILE NAME? EVA272↓ *(Input Data Storage File Name)*

4.  
EXEL FILE NAME? EVA272↓ *(Input Exel File Name)*

\*\*\*\*\*  
The Transducer Must Be Unloaded To Scan Initial Offsets  
\*\*\*\*\*

5.  
If Transducer Is Unloaded Hit 'Y'? Y↓
  1. Before Responding To Above, Hit Any Key On GSE:Data-Stat If It Displays "Press any key to continue".
  2. Enter 'Y' If Transducer is unloaded. Else Unload It and Then Hit 'Y'. User Will Get 5 Chances To Unload The Transducer. After That The Program Will Terminate.)

Initial Offset of Set-up Is = 0.00007324 Volts

\*\*\*\*\*

Data Will Be Stored In EVA2721.DAT

Data For Cricket Graph Will Be In EEX2721.DAT

After Quitting The Program, Rename The Data Files

\*\*\*\*\*

(File Extensions 1.DAT Will Be Automatically Added To The User File Names Entered Earlier In Step 2 and 3.. The Numeric Extension Will Change By An Increment of One For Every Iteration For Data Acquisition Hereafter.)

6.

Record Comments/Titles If Any:? A1 CW TORQUE/ANGLE↓

(Title For Data Being Acquired)

7.

Total time in seconds for data acquisition:? 30↓

(a. 15 Seconds For Speed Measurement

b. 30 Seconds For Torque/Angle Measurements)

8.

READINGS PER SECOND SHOULD BE LESS THAN: 33

READINGS PER SECOND:? 20↓

(a. 1 Reading Per Second For Speed Measurement

b. 30 Readings Per Second For Torque/Angle Measurements)

9.

(At This Point Software Is All Set To Collect The Data. The Magnetic Particle Brake Switch Will Be "ON". The Brake Controller Knob Will Be In Its Zero Position.)

Hit Any Key If Ready To Go:?↓

(If The Measurement Is Of Speed (RPM), Then User Notes Down The RPM Displayed On The Computer Screen. If The Measurement Is Of TORQUE/ANGLE Then The User Gradually Stalls PRT By Turning The Brake Controller Knob In Clockwise Direction. For The Present Application User Will Stall PRT 3 Times In Succession In 30 Seconds. All The Pertinent Data Will Be Displayed In Real Time As Is Shown In Step 10.)

10.

scanning channels for data.....

\*\*\*\*\*

Reading No. = 15

\*\*\*\*\*

Controller Pulse = 8

\*\*\*\*\*

RPM (Average) = 26.666  
 \*\*\*\*\*  
 Degrees = 475  
 \*\*\*\*\*  
 Torque (Ft.Lbs) = 7.896  
 \*\*\*\*\*  
 Peak Torque (Ft.Lbs) = 10.666  
 \*\*\*\*\*

11.

The Above Readings Are Taken In 30 Seconds  
 Starting at 03:30:28 And Ending At 03:30:58

*(General Information Is Displayed)*

12.

MAX (Ft.Lbs)	MIN(Ft.Lbs)	MAX(Degrees)	RPM
10.666	0.216	576	26.666

*(The Information Above Displayed Shows Either Peak Or Maximum Valued  
 Attained During The Data Acquisition)*

13.

*(Hit Return (↓) To Display The Torque/Angle Graph For The Data Collected. Hit  
 Return (↓) To Quit The Torque/Angle Graph.*

14.

Hit 'Y' To Redisplay The Graph: Y↓

*(Hit Y↓ AND ↓ To Display The Torque/Angle Graph Again For The Data Collected,  
N↓ To Proceed Further.*

15.

*(Hit Return (↓) To Quit The Torque/Angle Graph For The Data Collected).*

16.

*(The Software Will Close All Data File: EVA 2721.DAT And EEX 2721.DAT And  
 Automatically Generate EVA2722.DAT and EEX2722.DAT For Next Cycle Of Data  
 Acquisition.)*